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# Coastal Engineering Technical Note

## FALL VELOCITY OF BEACH SANDS

PURPOSE: To present an improved method for estimating the terminal fall velocity of any beach sand. Fall velocity is used in predicting the occurrence of accreted (berm) or eroded (bar) nearshore profiles; see Section 4.525c of the *Shore Protection Manual*. Although definitive methods for engineering application have not yet been established, the fall velocity is expected to figure in the dimensions of bed forms and in the sediment transport.

BACKGROUND: Standard guidance on the value of fall velocity is provided for spheres of a given material in a given fluid; for example, Figure 4-31 of the SPM presents the fall velocity of quartz spheres in freshwater at several temperatures. A recent review of available measurements resulted in a set of simple equations giving fall velocity for common angular sediment grains. This more general and convenient guidance will be summarized here, and an example calculation presented.

GIVEN GUIDANCE: To estimate fall velocity,  $V_f$ , the following material characteristics must be specified:  $\rho_s$  = sediment density;  $\rho$  = fluid density;  $\nu$  = fluid kinematic viscosity; and  $M_d$  = sediment median grain diameter. To determine which of the three equations should be used, the grain buoyancy,  $A$ , must be determined using the following equation:

$$A = \frac{(\rho_s - \rho) g M_d^3}{\rho \nu^2}$$

where  $g$  = acceleration of gravity. The fall velocity equations and their ranges of applicability are:

$$V_f = \frac{(\rho_s - \rho) g M_d^2}{18 \rho \nu} \quad \text{for } A < 39 \quad (1)$$

$$V_f = \frac{\left[ \frac{(\rho_s - \rho)g}{\rho} \right]^{0.7} M_d^{1.1}}{6 v^{0.4}}, \text{ for } 39 < A < 10^4 \quad (2)$$

$$V_f = \left[ \frac{(\rho_s - \rho)g M_d}{0.91 \rho} \right]^{1/2}, \text{ for } A > 10^4 \quad (3)$$

Any consistent units may be used in these relationships. Common values of  $\rho$  and  $v$  for freshwater and for 33 parts per thousand (ppt) saltwater are listed in the table. The value of  $g$  is  $981 \text{ cm/sec}^2$ . Common values of  $\rho_s$  are  $2.65 \text{ gm/cm}^3$  for quartz and  $2.7$  to  $2.8 \text{ gm/cm}^3$  for shell material. Equation (2) will usually be applicable in freshwater or saltwater for fine to coarse quartz sand, i.e.,  $M_d$  between  $0.125$  and  $1 \text{ mm}$ .

Table. Common Fluid Characteristics

Temperature °C	Freshwater		33 ppt Saltwater	
	$\rho$ , gm/cm <sup>3</sup>	$v$ , cm <sup>2</sup> /sec	$\rho$ , gm/cm <sup>3</sup>	$v$ , cm <sup>2</sup> /sec
5	1.0000	0.0151	1.028	0.0157
10	0.9997	0.0130	1.027	0.0135
15	0.9991	0.0114	1.026	0.0119
20	0.9982	0.0100	1.025	0.0105
25	0.9969	0.0089	1.024	0.0095

\*\*\*\*\* EXAMPLE \*\*\*\*\*

GIVEN: Quartz sand of  $M_d = 0.02 \text{ cm}$  ( $0.20 \text{ mm}$ ) in  $20^\circ\text{C}$  freshwater;

FIND: The value of fall velocity,  $V_f$ .

SOLUTION: Using values from the table, the value of  $A$  is computed as:

$$A = \frac{(\rho_s - \rho)g M_d^3}{\rho v^2} = \frac{(2.65 - 0.998)981(0.02)^3}{(0.998)(0.0100)^2} = 130,$$

so that Equation (2) is appropriate, and

$$V_f = \frac{\left[ \frac{(\rho_s - \rho)g}{\rho} \right]^{0.7} M_d^{1.1}}{6 v^{0.4}} = \frac{\left[ \frac{(2.65 - 0.998)981}{0.998} \right]^{0.7} (0.02)^{1.1}}{6(0.0100)^{0.4}} = 2.51 \text{ cm/sec or } 0.082 \text{ ft/sec}$$

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#### REFERENCES:

HALLERMEIER, R.J., "Terminal Settling Velocity of Commonly - Occurring Sand Grains," *Sedimentology*, 1981, in press.

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vols. I, II, and III, Stock No. 008-022-0113-1, U.S. Government Printing Office, Washington, D.C., 1977, pp. 4-81 to 4-84.